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Preliminary Report on the Fishes of the Upper Saline River, Polk and Howard Counties, Arkansas, and Observations on Their Relationships with Land Use and Physiochemical Conditions

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PRELIMINARY REPORT ON THE FISHES OF THE UPPER SALINE RIVER, POLK AND HOWARD COUNTIES, ARKANSAS, AND OBSERVATIONS ON THEIR RELATIONSHIPS WITH LAND USE AND PHYSICOCHEMICAL CONDITIONS

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ABSTRACT

The Saline River of southwest Arkansas was impounded by Dierks Lake in 1975. Intensive collecting efforts were made in the river system above Dierks Lake during March, April, and May 1980. Collected specimens were compared with ichthyofaunal lists prior to impoundment. Historic occurrants which were not collected include *Notropis amnis, Notropis ortenburgeri, Moxostoma duquesnei, Ammocrypta vivax,* and *Percina copelandi.* Additions to the ichthyofaunal list for the drainage include *Fundulus notatus, Etheostoma spectabile,* and *Percina caprodes.* The evidence indicates that 33 species representing six families inhabit the system from the headwaters in Polk County, Arkansas, to Dierks Lake, Howard County, Arkansas. Erosion within the basin ranges from 956 kilograms per hectare per year on grassland to 158,263 kilograms per kilometer per year on roadbanks. Excessive levels of fecal coliform bacteria, cadmium, copper, lead, zinc, and sulfates were noted within the system. The relationship of these factors to the ichthyofauna is discussed.

INTRODUCTION

Studies involving the fishes of the Saline River are limited, confined to several early studies (Meek, 1891; Hubbs and Ortenburger, 1929; Black, 1940) and those summarized by Buchanan (1973). Collections made during this study expand the ichthyofaunal list for the upper Saline River.

The upper Saline River drains approximately 293 km^2 in northern Howard County and extreme southern Polk County, Arkansas. The stream flows approximately 21 km from the headwaters in the Ouachita National Forest near Shady Lake Recreational Area to Dierks Lake, 8 km northwest of Dierks, Arkansas. Storage began in Dierks Lake 8 May 1975. Stream flow is continuous within the system ranging from about 0.06 m^3/sec in late summer-early fall to 34 m^3/sec in the spring (USGS, 1975-1979).

The basin involves 25,923 hectares and is characterized by narrow, winding ridgetops, rolling to steep wooded mountainsides and narrow stream valleys. Sherwood-Pickens soil associations cover the area and are composed of well-drained Sherwood soils (44%), excessively-drained Pickens soils (25%) and rockland (31%). Slopes range from 8 to 50%, and the depth to sandstone or shale bedrock is 13-23 cm in many areas. Due to severe erosion hazards and coarse fragments which make tillage difficult, this association is not well suited to farming. The area is best suited to woodland, and forests cover 90-95% of the area (Hoelschler et al., 1975).

Physicochemical conditions within the system are fairly typical of Ouachita Mountain streams. The water is soft, containing 26-100 ppm dissolved solids, and the stream is classified as a calcium-bicarbonate type (Rainwater, 1962). Dissolved oxygen concentrations range from summer lows around 4 mg/1 to winter highs around 12 mg/1. Alkalinity values range between 8 and 26 mg/1 ($CaCO_3$). Turbidity levels are typically low, 12-155 JTU, but high runoff periods in spring and winter produce short-term peak loads above 350 JTU (USGS, 1975-1979). Temperatures range from 2-20°C (mean 16°C) in the stream.

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METHODS AND MATERIALS

Thirty-seven fish samples were taken in the system during March, April, and May 1980. Eleven stations on the upper Saline River and two headwater streams (stations 1-4) were sampled (Fig. 1). Standard minnow seines, 3.0, 4.6, and 6.1m in length, and 1.2m in depth were used for sampling. Station locations were: station 1-T4S R28W sect. 30, Polk Co.; station 2-T4S R28W sect. 30, Polk Co.; station 3-T4S R28W sect. 29, Polk Co.; station 4-T4S R28W sect. 29, Polk Co.; station 5-T4S R28W sect. 31, Howard Co.; station 6-T5S R28W sect. 8, Howard Co.; station 7-T5S R28W sect. 16, Howard Co.; station 8-T5S R28W sect. 33, Howard Co.; station 9-T6S R28W sect. 5, Howard Co.; station 10-T6S R29W sect. 25, Howard Co.; station 11-T6S R29W sect. 33, Howard Co.

Spot water quality samples were taken during April sampling periods using a Hach DR-EL/2 portable laboratory. Additional water quality data were provided by the U. S. Geological Survey, Little Rock, Arkansas, for water years 1975-79.

Land use data were provided by the U. S. Soil Conservation Service. These data were collected during a nationwide Resource Inventory Data System (RIDS) effort in association with the Soil and Water Resource Conservation Act (RCA) of 1977, PL 95-192 (Evans, 1981). Erosion rates were calculated by IBM360 computer and are similar to rates obtainable using the Universal Soil Loss Equation (USLE) developed by the U. S. Department of Agriculture.

All specimens collected were preserved in 10% formalin for 2-5 days, washed, and stored in 40% isopropanol. Specimens are stored in the Arkansas State University Museum (ASUMZ) and the U. S. Courthouse, Nashville, Tennessee. All of them eventually will be maintained in the ASUMZ collection.

RESULTS

Thirty-three species of fishes representing six families were either collected during this study or reported by previous authors. An annotated list of these species follows. Nomenclature follows Bailey et al., (1970). Station numbers of collection sites follow the species

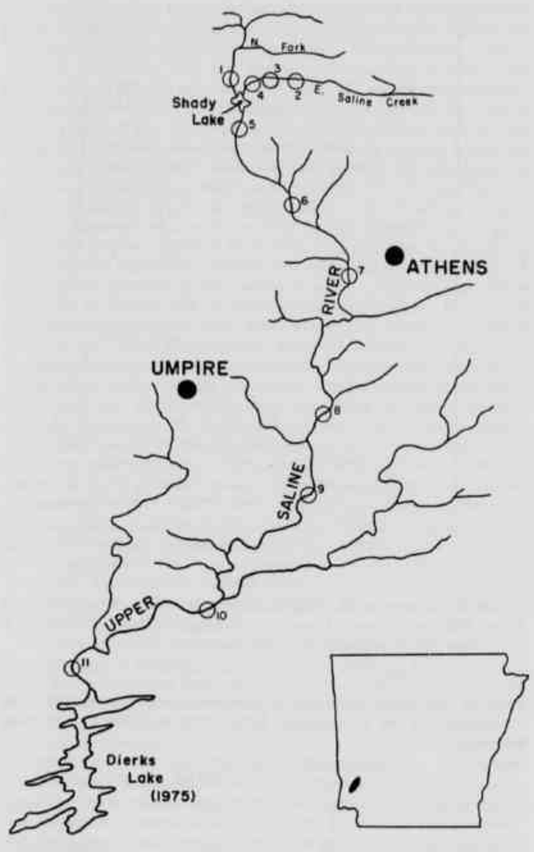

Figure 1. The upper Saline River watershed, Polk and Howard Counties, Arkansas, and collecting stations used in this study.

names and, with notations, provide a brief description of relative abundance.

ANNOTATED LIST OF SPECIES COLLECTED

CYPRINIDAE

Campostoma anomalum (Rafinesque) - Stoneroller- 5,6,7,8,9,10.
Fairly common in middle reaches below Shady Lake.

Notropis amnis Hubbs and Greene - Pallid shiner- not collected.
Extremely rare or absent. Historically occurs in extreme headwater regions.

Notropis atherinoides Rafinesque - Emerald shiner- 6,7,8.
Fairly common in upper reaches below Shady Lake.

Notropis boops Gilbert - Bigeye shiner- 2,3,5,6,7,8,9,10,11.
Common. Most common minnow, collected throughout.

Notropis chrysocephalus (Rafinesque) - Striped shiner- 3,5,6,7,8,9,10,11.
Common. Collected throughout.

Notropis ortenburgeri Hubbs - Kiamichi shiner- not collected.
Extremely rare or absent. Historically occurs in headwater pools commonly with large rocks.

Notropis umbratilis (Girard) - Redfin shiner- 7,8,9,10.
Common in middle reaches usually in pools over sand or gravel bottoms.

Notropis whipplei (Girard) - Steelcolor shiner- 7,8,9.
Common in middle reaches.

Pimephales notatus (Rafinesque) - Bluntnose minnow- 9,10,11.
Fairly common in lower reaches in pools and slower current.

Pimephales tenellus (Girard) - Slim minnow- 10,11.
Rare in lower reaches, taken in water over 2′ in depth and in small numbers.

Pimephales vigilax (Baird and Girard) - Bullhead minnow- 9,10,11.
Common in lower reaches over sand or silt bottoms.

Semotilus atromaculatus (Mitchell) - Creek chub- 1,4.
Rare. Collected only in the extreme upper reaches in tributaries above Shady Lake.

CATOSTOMIDAE

Erimyzon oblongus (Mitchell) - Creek chubsucker- 9,10,11.
Fairly common in lower reaches in slow current or pools with detritus deposits.

Moxostoma duquesnei (LeSueur) - Black redhorse- not collected.
Extremely rare or absent. Historically occurs in lower reaches over sand or gravel bottoms.

Moxostoma erythrurum (Rafinesque) - Golden redhorse- 11.
Rare, taken only in extreme lower reaches and in small numbers.

ICTALURIDAE

Ictalurus natalis (LeSueur) - Yellow bullhead- 7,8,9,10.
Fairly common in middle reaches in pools and slow currents over all bottom types.

Noturus nocturnus Jorden and Gilbert - Freckled madtom- 9,10,11.
Rare in lower reaches over sand, gravel, or silt bottoms with detritus deposits.

ATHERINIDAE

Labidesthes sicculus (Cope) - Brook silverside- 9,10,11.
Common in lower reaches over sand, gravel, or silt bottoms.

Menidia audens Hay - Mississippi silverside- 10.
Rare in lower reaches over bottoms with detritus deposits.

CYPRINODONTIDAE

Fundulus catenatus (Storer) - Northern studfish- 9,10.
Extremely rare. Historically occurs in shallow pools and backwaters. Only two specimens collected.

Fundulus notatus (Rafinesque) - Blackstripe topminnow- 9,10.
Rare in lower reaches, in or near pools or elbows.

Fundulus olivaceus (Storer) - Blackspotted topminnow- 8,9,10,11.
Common in the lower reaches in slower current and often with *F. notatus*.

CENTRARCHIDAE

Lepomis cyanellus Rafinesque - Green sunfish- 4,5,6,7,8,9,10,11.
Common throughout in all habitat types.

Lepomis macrochirus Rafinesque - Bluegill- 3,4,5,6,7,8,9,10.
Common throughout in all habitat types.

Lepomis megalotis (Rafinesque) - Longear sunfish- 3,4,5,6,7.
Fairly common in upper reaches, usually in pools over rock bottoms.

Micropterus dolomieui Lacepede - Smallmouth bass- 6,7,8,9,10.
Fairly common in all reaches except extreme upper reaches above Shady Lake.

Micropterus salmoides (Lacepede) - Largemouth bass- 11.
Rare, occurring only at most extreme lower station possibly as migrants from Dierks Lake.

PERCIDAE

Ammocrypta vivax Hay - Scaly sand darter- not collected.
Extremely rare or absent. Historically occurs in lower reaches over sand bottoms.

Etheostoma radiosum (Hubbs and Black) - Orangebelly darter- 2,3,5,6,7,8,9,10.
Common in all but extreme upper and lower stations. Not collected above Shady Lake.

Etheostoma spectabile (Agassiz) - Orangethroat darter- 5,6,9,10.
Fairly common in middle reaches over gravel bottoms.

Etheostoma whipplei (Girard) - Redfin darter- 5,6,7,8,9,10.
Common below Shady Lake over sand or gravel bottoms.

Percina caprodes (Rafinesque) - Logperch- 8,9,10,11.
Common in lower reaches typically in slower currents and commonly associated with detritus deposits.

Percina copelandi (Jordan) - Channel darter- not collected.
Extremely rare or absent. Historically occurs in lower reaches typically over sand, occasionally gravel bottoms.

Water quality data indicate that 5 parameters exceed recommended criteria for support of aquatic ecosystems (EPA, 1976; FWPCA, 1968), and a sixth presents a health hazard for bodily contact with the water. A summary of these criteria used to determine acceptable levels appears in Table 1. Data indicate that levels of some toxic heavy metals had increased steadily within the system following the impoundment of the upper Saline River by Dierks Lake (Fig. 2) until 1979, when conditions began to stabilize. Fig. 2 illustrates conditions at the confluence with Dierks Lake.

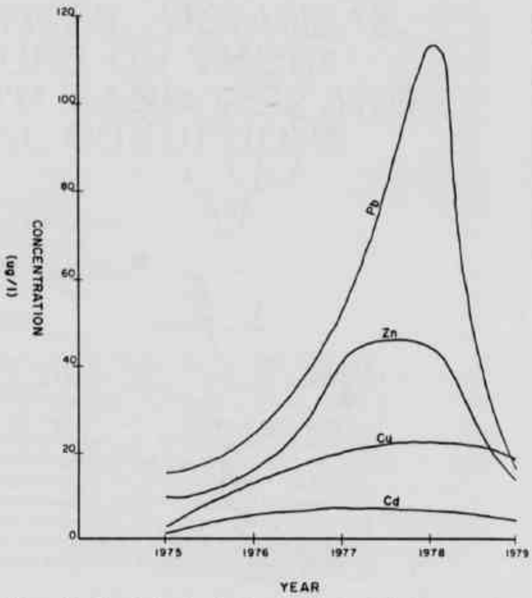

Figure 2. Yearly levels of selected metals within the upper Saline River, Polk and Howard Counties, Arkansas, 1975-1979 (Pb = lead; Zn = zinc; Cu = copper; Cd = cadmium).

Table 1. Levels of water quality parameters requiring concern and criteria used in the upper Saline River, Polk and Howard counties, Arkansas.

PARAMETER	LEVELS OBSERVED (u 1975-79)	ACCEPTABLE LEVEL FOR AQUATIC SYSTEMS	SOURCE OF CRITERION
Fecal Coliform bacteria	506	400[a]	EPA,1976
Turbidity (JTU)	34[b]	50[c]	FWPCA,1968
Alkalinity (mg/l $CaCO_3$)	20.18	20, except where natural state is less	EPA,1976
Chlorine (mg/l Cl)	5.75	10	EPA,1976
Cadmium (ug/l Cd)	4.98	4	EPA,1976
Copper (ug/l Cu)	15.04	5[d]	EPA,1976 Pickering and Henderson,1966
Lead (ug/l Pb)	43.44	2[e]	EPA,1976 Pickering and Henderson,1966
Zinc (ug/l Zn)	25.26	8[e]	EPA,1976 Pickering and Henderson,1966
Sulfate (mg/l SO_4)	18.00	2[f]	EPA,1976

[a]Criterion for bathing. No criterion for aquatic organisms.
[b]Short duration peaks in spring-early summer and winter high water periods may exceed 350 JTU
[c]Standard established by EPA = sufficient turbidity to reduce light penetration by 10%
[d]Based on 0.1×96hr LC_{50} of most sensitive species present as determined by non-aerated bioassay.
[e]Based on 0.01×96hr LC_{50} for most sensitive resident species.
[f]Criterion for undissociated H_2S

RIDS information indicates that silviculture and associated businesses dominate commercial activities within the basin. Forests are approximately 83% loblolly-shortleaf pine. Thirty percent of these are 0-10 years old, 39% are poorly to moderately stocked, and roughly 6% (1234 ha) are disturbed annually. These statistics illustrate the intensification in silvicultural operations within the basin in recent years. Since the banning of 2,4,5-T, several replacement chemicals have been used and tested in these operations within the watershed (Evans, 1981). Examples are Tordon 101 (picloram, 4-Amino-3,5,6-trichloropicolinic acid), Garlon 3A (silvex, 2-[2,4,5-trichlorophenoxy] propionic acid), and 2,4,DP Weedone II (2,4-dichlorophenoxyacetic acid, methyl ester) (ChemService, Inc., 1981). The active ingredient in Tordon 101, picloram, is one of the most effective chemicals available for converting low quality hardwood forests to commercial species (Lawson and Ferguson, 1972). Each liter of Tordon 101 contains 0.06 kg of picloram. Picloram is fairly persistent in forest soils, especially during drought conditions (Neary et al., 1979). Furthermore, picloram adsorption is increased in soils high in organic matter, further slowing leaching processes. In this situation, picloram may remain for several months in the upper 30-60 cm of soil, which becomes soil loss during the erosion process, and may be laden with picloram upon entry into stream systems (Evans and Duseja, 1973). Although not persistent in the aquatic environment, picloram concentrations as low as 35 ug/1 affects yolk sac adsoprtion by fry of some species (Johnson and Finley, 1980). Silvex accumulates in fat, muscle, liver, and kidney tissues in livestock (Menzie, 1980). Toxicity to fish has been reported with concentrations as low as 0.36 mg/1 (Stewart, 1975), and action by a mixed culture of organisms is required to degrade it rapidly in the aquatic environment. Degradation releases chloride and CO_2. Weedone II is not persistent in soils, but may be toxic to fish at concentrations of 4.0 mg/1 (Stewart, 1975).

Land use within the basin has changed very little in the years since impoundment of Dierks Lake. Urban and built-up areas total less than 1%. Predominant land uses are forestland (93%) and grassland (7%). Forested acres have increased by an average of 3% per year since 1975, with a corresponding decrease in grassland acreage. Gross erosion also had increased during this period by 5% per year to the present rate of 2.06×10^8 kg per year, basinwide. Silvicultural activities, particularly forest harvesting operations and road construction, can accelerate transport of soil material downslope by soil mass movement (Overcash and Davidson, 1980). An increase in service roads, spur roads, and skid trails has contributed significantly to the erosion problem within the basin. These roads, totaling 312 km, erode at an average rate of 196,014 kg/km/yr. The accepted criterion for identifying severe conditions is 96,030 kg/km/yr (Evans, 97,812 kg/ha/yr. Unfortunately, as these areas become revegetated, ment resulting from timber harvesting activities (Stone et al., 1978). Other sources accompanying harvest intensification are associated with the heavy machines required to offset a dwindling labor force by allowing a small crew with complimentary machines to cut, process into the desired dimensions, load, and transport the timber at tenfold the rate of hand labor (Saucier, 1980). As a result, acres disturbed by harvesting operations are eroding at a rate in excess of 97,812 kg/ha/yr. Unfortunately, as these areas become revegetated, other problems develop. As sediment is decreased by upland erosion control measures, including reforestation, more energy becomes available for other processes within the stream itself, particularly streambed and bank erosion (Grissinger and McDowell, 1969; McDowell and Grissinger, 1976). A streambank within the basin of 202 km is currently eroding at a rate of 113,457 kg/km/yr. Sediment from these and upland sources damages aquatic environments by scour, burial, and abrasion (Ritchie, 1972). The substrate and associated organisms may be removed, detached, and/or carried away by the erosion process. Photosynthetic and food source organisms may be buried by accumulating sediment or killed by abrasion during the course of sediment movement (Brockway, 1979). Erosion problems within the upper Saline are summarized in Table 2.

Table 2. Average annual gross erosion summary for the upper Saline River watershed, Polk and Howard counties, Arkansas.

SITE	UNIT MEASURE (hectares)	KILOGRAMS PER UNIT MEASURE	TOTAL KILOGRAMS
Grassland	1823	956	1.74×10^6
Forestland	24101	4957[a]	1.19×10^8
	25924		1.22×10^8
	(kilometers)		
Streambank	202	113457	2.29×10^7
Road surfaces	312	37943	1.18×10^7
Roadbanks	312	158263	4.94×10^7
		TOTALS	2.06×10^8

[a]Distributed forestland (u = 1234 ha/yr) erodes at a rate of 97812 kg/ha/yr.

DISCUSSION AND CONCLUSIONS

Factors affecting the fishes and other stream organisms in the upper Saline River are contributing to an overall decline in numbers of species and organisms. Among these factors are excessive metal introduction, excessive erosion and sedimentation, possible herbicide contaminations for short periods, and contamination by agricultural and domestic wastes.

Area fish species which may have been affected by these factors include *N. amnis*, *N. ortenburgeri*, *M. duquesnei*, *A. vivax*, and *P. copelandi*. These species were not collected in this study. Species collected in this study which were not previously reported in the upper Saline River include *F. notatus*, *E. spectabile*, and *P. caprodes*. Further collecting efforts may reveal additional species.

Land use within the drainage has had a marked effect on the aquatic ecosystems. The pristine conditions normally associated with forested, virtually unsettled drainage basins are disappearing from the upper Saline River drainage due to both intensified use of remaining agricultural lands and conversions of low grade hardwood forests to commercial species. In the former case, small farming operations have been supplemented by poultry production for economic purposes. Most of these farms do not have proper waste management systems or facilities for storing or disposing of dead birds (Evans, 1981). In the latter case, roughly 72% of all timber lands within the basin are owned by a single timber company. Maximum production on these acres has resulted in severe erosion problems from both maintenance of traffic lanes for heavy equipment and annual disturbance of approximately 1234 forested hectares.

Bare rock outcrops, unprotected escarpments, and gravel operations are possible sources for the excessive levels of metals noted in the upper Saline River. Concentration of these substances in Dierks Lake since impoundment has created conditions unsuitable and often toxic to aquatic life (Table 2 and Fig. 2). Lead, zinc, cadmium, and copper have been found in excessive amounts in Dierks Lake since its creation and are toxic to aquatic organisms. Lead enters the aquatic environment through precipitation, lead dust fallout, erosion and leaching of soil, and other pathways associated with large cities. Zinc usually is found in nature as a sulfide and is often associated with the sulfides of other metals, particularly lead, cadmium, copper, and iron. Cadmium occurs in nature chiefly as a sulfide salt, frequently associated with zinc and lead ores. Accumulations in soils in the vicinity of mines and smelters may cause high level concentrations in nearby waters. Copper occurs as a natural, or native, metal and in various mineral forms such as cuprite and malachite. The most important copper ores are sulfides, oxides, and carbonates (EPA, 1976).

Specific effects of these pollutants on the fishes of the upper Saline River are not quantified herein, however some general conclusions are noted regarding the species considered very rare or not collected during this study. *Notropis amnis* has not been reported in large numbers from any locality within its range (Miller and Robison, 1973), but where found, it tends to avoid swift currents and to intolerate excessive siltation and turbidity. Increases in these latter parameters have contributed to *N. amnis'* showing the most marked decline of any Missouri fish in recent years (Pflieger, 1975). However, historic occurrence of this fish in the study area was in the extreme headwater region, and a more logical explanation for its decline would be the construction of Shady Lake Recreational Area. Similar habitat requirements appear to apply to *N. ortenburgeri*, but specifics of its life history and habits are lacking (Miller and Robison, 1973). *Moxostoma duquesnei* is intolerant of turbidity and pollutants. Young of this species are dependent on stable backwater areas, where they feed on algae and small crustaceans. Siltation is increased in these areas in the upper Saline River as reductions in current allow suspended sediment to settle out. As a result, these habitats and food sources are reduced or absent and young mortality increases. Also, adult habitat preferences, in the lower mainstem, have exposed members of this species to the conditions illustrated in Table 2 and Fig. 2. The northern studfish, *F. catenatus*, is more of a bottom feeder than other topminnows (Pflieger, 1975), taking the majority of its food from silt-free sand, gravel, or rock bottoms (McCaskill et al., 1972). These areas have been drastically reduced by siltation in the upper Saline River. *Percina copelandi* also requires silt-free gravel or rock bottoms in slow mainstem currents. Abundant chironomids, other insect larvae, and microcrustaceans are preferred food sources (Miller and Robison, 1973). Eggs are laid in sand bottoms in the spring and deserted. These requirements are seriously lacking in the upper Saline, and, due to the instability of available sand bottoms in the stream, spawning success may have been affected. The Scaly sand darter, *A. vivax*, will bury in the sand bottoms out of strong current, but it is intolerant of siltation and turbidity (Pflieger, 1975). Exposure of both *P. copelandi* and *A. vivax* to the toxic levels noted in Table 2 and Fig. 2 during the early years of Dierks Lake has probably been a causal factor for their decline (Tarzwell and Henderson, 1960).

Future environmental degradation can be avoided in the basin only if problem areas are addressed in the near future. These areas include the need for proper waste management on existing agricultural lands, roadbank stabilization, erosion control during the harvesting and revegetation operations on forestland, preservation of a riparian vegetation zone as a natural filter strip, and control of runoff from mining and/or gravel operations. The techniques involved and their environmental values have been adequately described by previous authors (Mader et al., 1972; Kochenderfer, 1970; Bednar and Fluke, 1980; Johnson and McCormick, 1978; Stern and Stern, 1980; Newbold et al., 1980).

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